

CLAIMS:

1. A method of downhole data communication in a well in which there is a flow of product from the formation towards the surface, the data
5 communication taking place between two locations in the flow path, at least one of which is downhole in the well, and the method comprising the steps of: controlling a flow rate of the product at a first of the two locations in dependence on data to be transmitted;
measuring, at the second of the two locations, the flow rate of the product to
10 detect variations in flow rate of the product at the second location caused by said controlling of the flow rate of the product at the first location; and using the results of the measuring step to extract the data transmitted.
2. A method according to claim 1 comprising the step of keeping the
15 nominal flow rate at the first location at a state for at least a minimum period chosen to allow this change in state to propagate to the second location.
3. A method according to claim 1 or claim 2 comprising the step of
altering the flow rate of the product at the first location by at least +/- 20%
20 about an average flow rate to encode data to be transmitted.

4. A method according to any preceding claim in which a valve is used in controlling the flow rate at the first location.
5. A method according to any preceding claim comprising the further steps
5 of:
controlling a flow rate of the product at the second location in dependence on data to be transmitted;
detecting, at the first location, the effect of said controlling of the flow rate of the product at the second location; and
10 using the results of the detecting step at the first location to extract the data transmitted.
6. A method according to any preceding claim in which the flow is modulated using a scheme arranged such that the average flow rate is that
15 required for production.
7. A method according to any preceding claim in which variations in flow rate created at the first location are applied in the form of tones.
- 20 8. A method according to any preceding claim comprising the step of communicating between a plurality of branches in a multi-lateral well and the

well head.

9. A method according to any preceding claim comprising the step of actively smoothing undesired fluctuations in the flow rate.

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10. A method according to claim 9 comprising the steps of using a valve to controllably restrict the flow rate at the first location, sensing a pressure in the region of valve and varying the flow restriction provided by the valve in dependence on the pressure sensed.

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11. A method according to claim 10 comprising the step of using a plurality of predetermined levels of flow rate in a signalling technique and varying the flow restriction provided by the valve in an aim to keep the flow rate at a selected one of the plurality of predetermined levels at any one time in accordance with the signals to be sent.

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12. Downhole data communication apparatus for use in a well in which there is a flow of product from the formation towards the surface and where the data communication takes place between two locations in the flow path, at least one of which is downhole in the well, the apparatus comprising: control means for controlling a flow rate of the product at a first of the two

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locations in dependence on data to be transmitted;
means for detecting, at the second of the two locations, the effect of controlling
of the flow rate of the product at the first location; and
means arranged to extract transmitted data using the output of the detecting
5 means.

13. Apparatus according to claim 12 in which said means for detecting
comprise a flow rate meter.

10 14. Apparatus according to claim 13 in which the flow rate meter comprises
a chamber, an elongate orifice having one end in fluid communication with the
chamber and another end exposable to the ingress of fluid from a fluid flow,
the flow rate of which flow is to be measured, and pressure sensing means for
sensing the pressure in the chamber.

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15. Apparatus according to claim 14 in which the pressure sensing means is
arranged for sensing the pressure across the orifice.

16. Apparatus according to claim 14 or 15 in which the pressure sensing
20 means is a differential pressure sensing means arranged to sense the differential
pressure between fluid in the chamber and fluid in the fluid flow in the region

of said other end of the orifice.

17. Apparatus according to any one of claims 12 to 16 wherein the means for controlling the flow rate comprise a valve.

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18. Apparatus according to any one of claims 12 to 17 further comprising: second location control means for controlling a flow rate of the product at the second location in dependence on data to be transmitted from the second location;

10 first location detecting means for detecting, at the first location, the effect of controlling of the flow rate of the product at the second location; and means arranged to extract data transmitted from the second location using the output of the first location detecting means.

15 19. Apparatus according to any one of claims 12 to 18 which is arranged to modulate flow rate using a scheme arranged such that the average flow rate is that required for production.

20 20. Apparatus according to any one of claims 12 to 19 in which the control means are arranged for applying variations in flow rate in the form of tones.

21. Apparatus according to any one of claims 12 to 20 arranged such as to allow communication between a plurality of branches in a multi-lateral well and the well head.
- 5 22. Apparatus according to any one of claims 12 to 21 in which the control means is arranged to actively smooth undesired fluctuations in flow rate.
23. Apparatus according to claim 22 in which the control means comprise a valve for controllably restricting the product flow rate, comprise a sensor for
10 sensing pressure in the region of the valve, and are arranged to vary the flow restriction provided by the valve in dependence on the pressure sensed.
24. Apparatus according to any one of claims 12 to 23 comprising a pump at the first location to aid in control of the flow rate at the first location and/or
15 a pump provided at the second location.
25. A method of downhole data communication in a well in which there is a flow of product from the formation towards the surface comprising the step of transmitting data by modulating the flow rate of the product to encode the
20 data.

26. Downhole data communication apparatus for use in a well in which there is a flow of product from the formation towards the surface and where the data communication takes place between two locations in the flow path, at least one of which is downhole in the well, the apparatus comprising:

- 5 a flow rate controller for controlling a flow rate of the product at a first of the two locations in dependence on data to be transmitted;
a flow rate detector disposed at the second of the two locations, for detecting the effect of controlling of the flow rate of the product at the first location; and
an analyser to extract transmitted data using the output of the detector.

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27. A flow rate meter comprising a chamber, an elongate orifice having one end in fluid communication with the chamber and another end exposable to the ingress of fluid from a fluid flow, the flow rate of which flow is to be measured, and pressure sensing means for sensing the pressure in the chamber.

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28. A flow rate meter according to claim 27 in which the the pressure sensing means is arranged for sensing the pressure across the orifice.

29. A flow rate meter according to claim 27 or 28 in which the pressure
20 sensing means is a differential pressure sensing means arranged to sense the differential pressure between fluid in the chamber and fluid in the fluid flow in

the region of said other end of the orifice.

30. A transmitter module for use in a producing well downhole communication method, the module being arranged for location at least partially in tubing carrying product and comprising a controllable valve for controlling the flow rate of product through the tubing and a control unit for controlling the valve and hence the flow rate in dependence on data to be transmitted.
- 10 31. A receiver module for use in a producing well downhole communication method, the module being arranged for location at least partially in tubing carrying product and comprising, a flow rate meter for measuring the flow rate of product through the tubing, and a control unit for analysing the output of the flow rate meter to extract data carried by variations of the flow rate.
- 15 32. A transceiver module for providing both transmit and receive functions in a producing well, the module being arranged for location at least partially in tubing carrying product and comprising a controllable valve for controlling the flow rate of product through the tubing, a flow rate meter for measuring the flow rate of product through the tubing, and a control unit for controlling the
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valve and hence the flow rate in dependence on data to be transmitted during transmission and for analysing the output of the flow rate meter to extract data carried by variations of the flow rate during reception.

- 5 33. A method of downhole data communication in a well in which there is a flow of product from the formation towards the surface, the data communication taking place between two locations in the flow path, at least one of which is downhole in the well, and the method comprising the steps of: controlling a flow rate of the product at a first of the two locations in
10 dependence on data to be transmitted;
measuring, at the second of the two locations, the flow rate of the product to detect variations in flow rate of the product at the second location caused by said controlling of the flow rate of the product at the first location; and using the results of the measuring step to extract the data transmitted, the
15 method comprising the further steps of altering the flow rate of the product at the first location by at least +/- 20% about an average flow rate to encode data to be transmitted and controlling the flow rate of the product at the first location in such a way as to apply tones to the flow having a frequency in the order of 0.1Hz or below.

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34. Downhole data communication apparatus for use in a well in which

there is a flow of product from the formation towards the surface and where the data communication takes place between two locations in the flow path, at least one of which is downhole in the well, the apparatus comprising:

- a flow rate controller for controlling a flow rate of the product at a first of the
- 5 two locations in dependence on data to be transmitted;
- a flow rate detector disposed at the second of the two locations, for detecting the effect of controlling of the flow rate of the product at the first location; and
- an analyser to extract transmitted data using the output of the detector, wherein the flow rate controller is arranged for altering the flow rate of the product at
- 10 the first location by at least $\pm 20\%$ about an average flow rate to encode data to be transmitted and moreover is arranged for controlling the flow rate of the product at the first location in such a way as to apply tones to the flow having a frequency in the order of 0.1Hz or below.